Predicting Student Success in Arcadia University's Math Courses

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Abstract

This project examines the relative efficacy of Arcadia's math placement test and math SAT scores in predicting student success, and explores whether SAT scores alone might suffice for certain courses.

1 Background

The background of our topic is that Arcadia University wants to know whether the Math placement test and Math SAT scores are equivalent on reflecting student success. According to the wide range of Math placement scores, SAT scores and grades of students choosing different courses, we examine the relative efficacy of Arcadia's Math placement test and Math SAT scores in predicting student success, and we explore whether SAT scores alone might suffice for certain courses.

2 The analysis of MA110, MA117, MA141, MA143, MA201.

The courses we analyze in this part are MA110 (Pre-calculus), MA117 (Math Concepts), MA141 (Elementary Statistics), MA143 (Business Mathematics), MA201 (Calculus I). We will analyze them using tables, probabilities and graphs.

2.1 MA110 Pre-Calculus

2.1.1 Table

We start from MA110, Pre-Calculus. We tried many models using multiple regression and for each model, Math SAT scores and the three placement scores have different predictor values. The table is as follows:

PREDICTORS	R^2
SAT (0.142)	0.078
PreCalc, PreAlg, Algebra (0.208) (0.236) (0.019)	0.32
CalcHS (0.107)	0.077
SAT, PreCalc, PreAlg, Algebra (0.13) (0.045) (0.604) (0.004)	0.442
SAT, CalcHS (0.134) (0.224)	0.13
PreCalc, PreAlg, Algebra, CalcHS (0.15) (0.272) (0.023) (0.104)	0.378
SAT, PreCalc, PreAlg, Algebra, CalcHS (0.145) (0.041) (0.731) (0.005) (0.301)	0.468

Figure 1: MA110 Pre-Calculus

In this table, on the left-hand side, we use P-value in the brackets to show whether the effects of these predictors are significant. For example, the P-value of SAT is 0.142, which is larger than 0.05 significance level, so SAT is not significant. In addition, P-values of the three placements are 0.208, 0.236 and 0.019 respectively, so Pre-Calculus and Pre-Algebra are not significant while algebra is significant. On the right-hand side, the value of R^2 illustrates the proportion of the variance of grades that can be explained by the predictors. As we can see, the R^2 value of SAT is 0.078 and the R^2 value of the three placements is 0.32. So, the three placements did a better job than SAT. And we find that combining SAT and the three placements together did the best job. What we should note is that the variable CalcHS, which indicated whether students had taken Calculus in high school with a grade of B or better, was included originally. But we found that the R2 of CalcHS was very low indicating that CalcHS was not significant in predicting

performance, so we dropped models including CalcHS. The modified table is below:

PREDICTORS	R^2
SAT (0.142)	0.078
PreCalc, PreAlg, Algebra (0.208) (0.236) (0.019)	0.32
SAT, PreCalc, PreAlg, Algebra (0.13) (0.045) (0.604) (0.004)	0.442

Figure 2: MA110 Pre-Calculus

2.1.2 Probability

Using the regression model to predict GPA based only on SAT, we find that the coefficients for SAT and GPA are 0.006 and -0.583, respectively. That is $GPA = -0.583 + 0.006SAT$, and students having an SAT score equal to 597.2 would be predicted to earn a 3 in the course.

Making use of logistic regression, we work out the relationship between probability of getting B and SAT scores:

$Prob = \frac{0.353(1.003)^{SAT}}{1+0.353(1.003)^{SAT}}$, where $Odds = 0.353(1.003)^{SAT}$

2.1.3 Graph

The graph below illustrates the probability of receiving B or better in MA110 based on SAT score. We should note the domain of this red line is (200,800) because SAT scores are between 200 and 800.

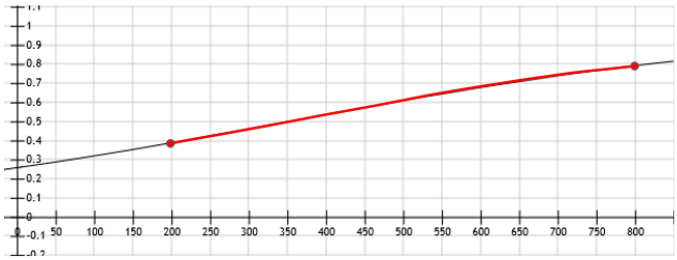

Figure 3: Graph of probability of receiving a B or better in MA110

2.2 MA117 Math Concepts

2.2.1 Table

Secondly, we examine MA117, Math Concepts. The table containing all the models is the following:

PREDICTORS	R^2
SAT (0.23)	0.021
PreCalc, PreAlg, Algebra (0.104) (0.014) (0.042)	0.165
CalcHS (0.965)	0.000025
SAT, PreCalc, PreAlg, Algebra (0.215) (0.094) (0.007) (0.02)	0.205
SAT, CalcHS (0.224) (0.801)	0.022
PreCalc, PreAlg, Algebra, CalcHS (0.121) (0.013) (0.03) (0.409)	0.172
SAT, PreCalc, PreAlg, Algebra, CalcHS (0.2) (0.109) (0.007) (0.012) (0.305)	0.217

Figure 4: MA117 Math Concepts

As with Pre-Calculus, we found that R^2 of calcHS is 0.000025, which is really low. This means that having Calculus in high school does not predict success in MA117. Therefore, we again dropped the models containing CalcHS. Although we still kept the data, we do not recommend using SAT or the 3 placements for MA117 because all R^2 are low in this table. Figure 5 shows the table after the adjustment.

PREDICTORS	R^2
SAT (0.23)	0.021
PreCalc, PreAlg, Algebra (0.104) (0.014) (0.042)	0.165
SAT, PreCalc, PreAlg, Algebra (0.215) (0.094) (0.007) (0.02)	0.205

Figure 5: MA117 Math Concepts

2.3 MA141 Elementary Statistics

2.3.1 Table

We now turn our attention to MA141, Elementary Statistics. From the table we can see all R^2 are low, even when we put all predictors together. So we do not recommend using SAT or the 3 placements for MA141. What's more, there is no need to calculate Math SAT score that would predict a 3.0(B) or make a graph in MA141 due to the low R^2.

PREDICTORS	R^2
SAT (0.048)	0.119
PreCalc, PreAlg, Algebra (0.16) (0.091) (0.000010)	0.135
CalcHS (0.000002)	0.056
SAT, PreCalc, PreAlg, Algebra (0.008) (0.367) (0.577) (0.023)	0.145
SAT, CalcHS (0) (0.021)	0.133
PreCalc, PreAlg, Algebra, CalcHS (0.237) (0.09) (0.000222) (0.067)	0.143
SAT, PreCalc, PreAlg, Algebra, CalcHS (0.012) (0.501) (0.567) (0.053) (0.13)	0.151

Figure 6: MA141 Elementary Statistics

2.4 MA143 Business Mathematics

2.4.1 Table

Next we analyze MA143, Business Mathematics. Figure 7 shows all the R^2 are moderately high. When we only consider SAT, we find that the R^2 value is 0.303 and thus the R value is 0.55. When we combine all predictors together, the $R^2 = 0.498$.

PREDICTORS	R^2
SAT (0.000035)	0.303
PreCalc, PreAlg, Algebra (0.02) (0.092) (0.223)	0.31
CalcHS (0.000005)	0.32
SAT, PreCalc, PreAlg, Algebra 0.018) (0.202) (0.367) (0.183)	0.421
SAT, CalcHS (0.005) (0.002)	0.437
PreCalc, PreAlg, Algebra, CalcHS (0.105) (0.089) (0.601) (0.001)	0.435
SAT, PreCalc, PreAlg, Algebra, CalcHS (0.088) (0.265) (0.3) (0.51) (0.014)	0.496

Figure 7: MA143 Business Mathematics

Therefore, we recommend that Arcadia uses SAT score together with the 3 placements to predict students' success in MA143.

2.4.2 Probability

For MA143, we consider the following two situations of computing the Math SAT score that would predict a 3.0(B).

(1) When we use the regression model to predict GPA based only on SAT, we find that the estimated coefficient for SAT is 0.011 and constant value is -4.105. That is $GPA = -4.105 + 0.011SAT$. From this, it follows that students would need an SAT score equal to 646 in order for their predicted grade in MA143 GPA to equal 3.

Making use of logistic regression, we work out the relationship between GPA and SAT scores:

$Prob = \frac{0.000003(1.022)^{SAT}}{1+0.000003(1.022)^{SAT}}$, where$Odds = 0.000003(1.022)^{SAT}$

(2)When we use the regression model to predict GPA based on both SAT and CalcHS, we find that the estimated coefficient of slope for SAT is 0.007, for CalcHS is 1.249 and constant value is -2.336. That is $GPA = -2.336+0.007SAT+1.249CalcHS$. Note from the above equation that when students had calculus and got a B in high school, we would predict that they would have 1.249 in GPA more than those who did not have Calculus in high

school. Furthermore, the SAT score of the students getting B with CalcHS is 584 while without it is 762.

Making use of logistic regression, we work out the relationship between GPA and SAT scores with CalcHS:

$Odds = 0.000032(1.016)^{SAT}(11.203)^{CalcHS}$

$Prob = \frac{0.000032(1.016)^{SAT}(11.203)^{CalcHS}}{1+0.000032(1.016)^{SAT}(11.203)^{CalcHS}}$

With CalcHS: $Prob = \frac{0.000358(1.016)^{SAT}}{1+0.000358(1.016)^{SAT}}$

No CalcHS: $Prob = \frac{0.000032(1.016)^{SAT}}{1+0.000032(1.016)^{SAT}}$

2.4.3 Graph

Below we present the graphs of the probability of receiving a B or better in MA143. It is clear that with CalcHS, the curve is higher than without it.

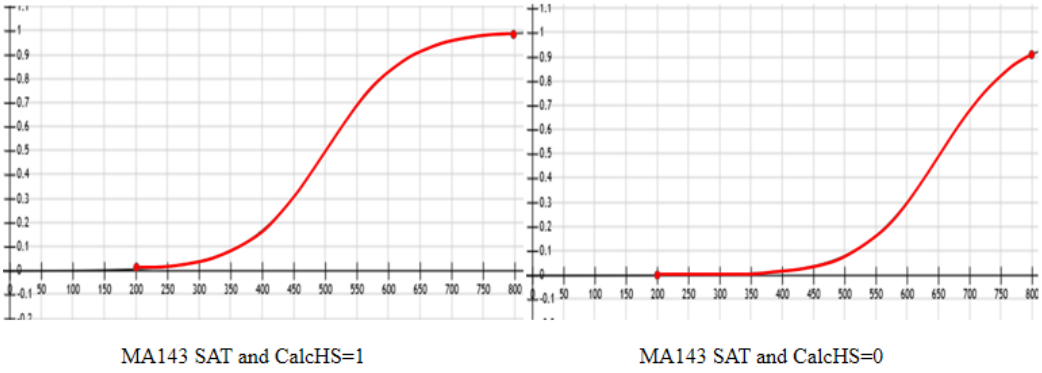

Figure 8: Graph of probability of receiving a B or better in MA143

2.5 MA201 Calculus I

2.5.1 Table

We now consider MA201, Calculus I. From Figure 9, we see that when all predictors are included in the model, R2=0.385 is high. Thus we recommend that Arcadia uses SAT scores together with the 3 placements to predict students' success in MA201.

PREDICTORS	R^2
SAT (0.000022)	0.179
PreCalc, PreAlg, Algebra (0.025) (0.193) (0.011)	0.16
CalcHS (0.000026)	0.157
SAT, PreCalc, PreAlg, Algebra (0.000323) (0.048) (0.015) (0.138)	0.28
SAT, CalcHS (0.000065) (0.000632)	0.278
PreCalc, PreAlg, Algebra, CalcHS (0.004) (0.063) (0.041) (0.000011)	0.307
SAT, PreCalc, PreAlg, Algebra, CalcHS (0.001) (0.011) (0.007) (0.255) (0.000199)	0.385

Figure 9: MA201 Calculus I

2.5.2 Probability

In MA201, we again consider the same two situations mentioned in MA143.

(1) When we use the regression model to predict GPA based only on SAT, we fins that the estimated coefficient of slope for SAT is 0.008 and constant value is -1.721. That is $GPA = -1.721 + 0.008SAT$, and students would need an SAT score equal to 590 for their predicted GPA to equal 3.

Making use of logistic regression, we work out the relationship between GPA and SAT scores:

$Prob = \frac{0.000112(1.016)^{SAT}}{1+0.000112(1.016)^{SAT}}$, where $Odds = 0.000112(1.016)^{SAT}$

(2)When we use the regression model to predict GPA based on both SAT and CalcHS, we obtained that the estimated coefficient of slope for SAT is 0.007, for CalcHS is 0.731 and constant value is -1.691. That is $GPA = -1.691 + 0.007SAT + 0.731CalcHS$. These findings are similar to those regarding MA143. Specifically, we see that when students had calculus with at least a B in high school, they would have 0.731 in predicted GPA more than those who did not have Calculus in high school. In addition, the SAT score of the students predicted to earn at least a B in MA201 with CalcHS is 566 while without is 670.

Making use of logistic regression, we work out the relationship between GPA and SAT scores with CalcHS:

$Odds = 0.000061(1.016)^{SAT}(2.922)^{CalcHS}$

$Prob = \frac{0.000061(1.016)^{SAT}(2.922)^{CalcHS}}{1+0.000061(1.016)^{SAT}(2.922)^{CalcHS}}$

With CalcHS: $Prob = \frac{0.000178(1.016)^{SAT}}{1+0.000178(1.016)^{SAT}}$

No CalcHS: $Prob = \frac{0.000061(1.016)^{SAT}}{1+0.000061(1.016)^{SAT}}$

2.5.3 Graph

Below are the graphs showing the probability of receiving a B or better in MA201 based on SAT score. They clearly indicate the value of having taken a calculus course in high school.

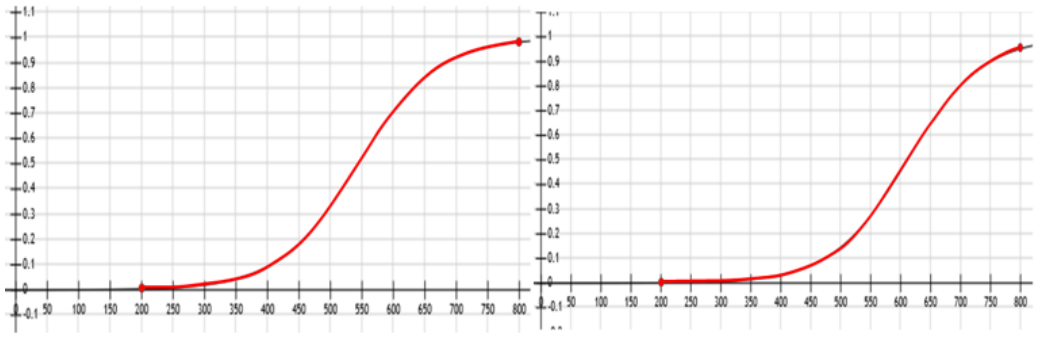

Figure 10: Graphs of probability of receiving a B or better in MA201

3 Graphs related with MA095 and MA100.

Next, we turn our attention to the developmental courses MA095 Pre-Algebra and MA100 Elementary Algebra. We use box plots and histograms to analyze the minimum SAT scores that should students to place out of these courses.

3.1 MA095

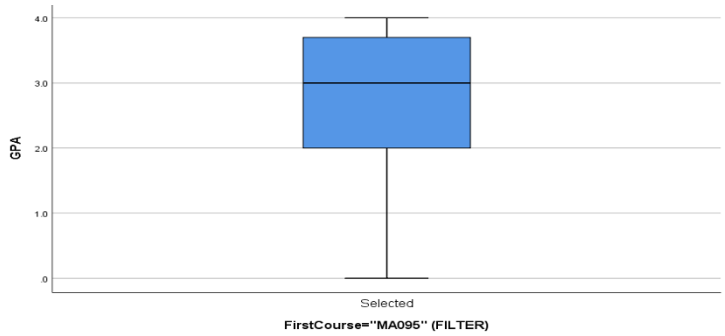

Figure 11: GPA in MA095

Figure 11 shows a box plot of the grades that students receive in MA095. The range of grade is from F to A and the median grade is a B. The first quartile happens to be a C and the third quartile happens to be a A-.

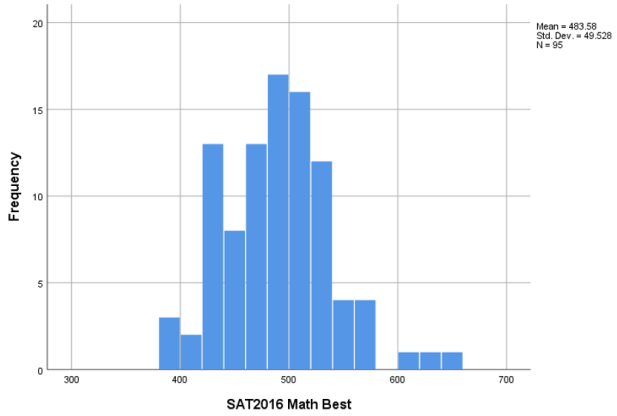

Figure 12: Math SAT score in MA095

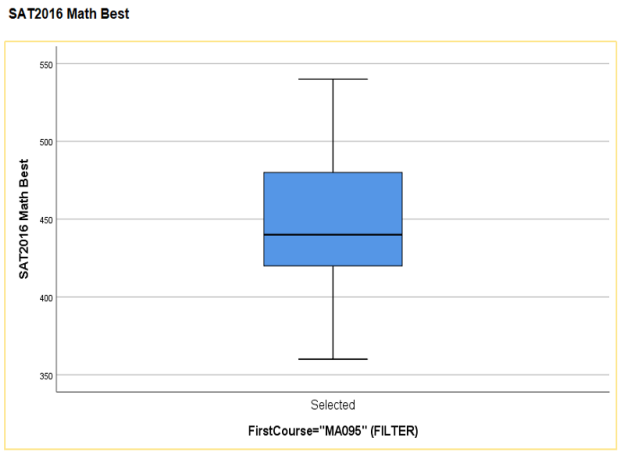

Figure 13: Math SAT score in MA095

Figure 13 shows the distribution of the students' SAT scores in MA095. The media score is 440 and the range of score is from 360 to 540. There is no student with a score more than 550.

We recommend that if a student obtains a SAT score more than 550, this student should place out of MA095.

3.2 MA100

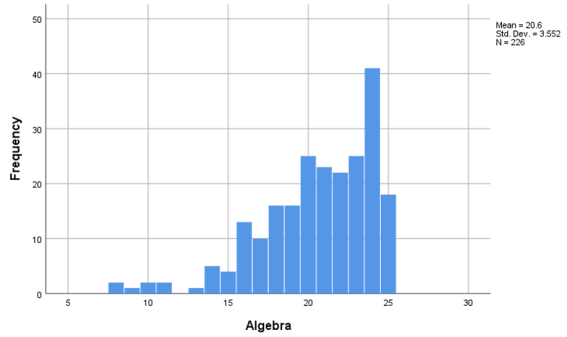

Figure 14: Math SAT score in MA100

Figure 14 is a histogram of the SAT scores of students who take MA100. The mean of these scores is approximately 484 and only three students' scores

are equal to or greater than 600.

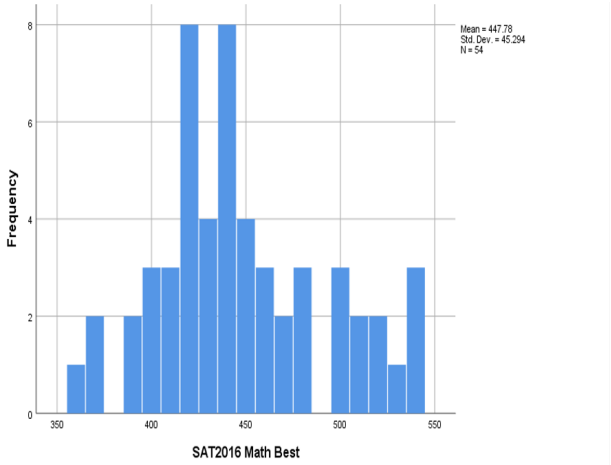

Figure 15: Algebra score

Figure 15 shows the distribution of algebra placement test scores of students scoring at least 600 on the Math SAT. We want to know how they did in the algebra section of the placement test. There are 25 questions in algebra and most of the students did very well. If a student has an SAT score of at least 600, they almost always scored at least 14 in the algebra section of the placement test and thus under current guidelines would be qualified to take more advanced courses.

We recommend that student having at least 600 in Math SAT should be able to take MA110 Pre-calculus or MA143 Business Mathematics without taking the Math placement test.

4 Summary

We found that for some courses, neither SAT nor the placement test accurately predicted success. But for others, they did predict success. We also looked at what minimum SAT scores might be to place out of MA095 or MA100.